deflecting each of said at least two light beams in a continuously changing direction so as to convert each of said at least two light beams into a scanning light beam; and

bringing the scanning light beam to a focus on a photoconductive surface using at least two scanning beam focusing mechanisms each of which satisfies an equation:

$\Delta L\cos\alpha < R/2$ at a junction of the scanning light beam with the other scanning light beam on the photoconductive surface,

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wherein ΔL represents an inherent light pass length variation between central light passage lengths of the first and second optical systems, α represents an incident angle, and R represents an inherent marginal distance.

REMARKS

Favorable reconsideration of this application as presently amended and in light of the following discussion is respectfully requested.

Claims 1-18 are pending in the present application with Claims 1, 4, and 7 having been amended by the present amendment.

In the outstanding Office Action, Claims 1-18 were rejected under 35 U.S.C. § 112, first paragraph, which is respectfully traversed.

First, Applicant notes the equation in the specification and claims have been amended to change the inequality sign ">" to "<" as the present inventor determined the original formula obviously included a translational error. It is respectfully submitted this change does not add new matter as it is clear the inequality should be "<" and not ">".

Further, in the previous response filed December 24, 2002, Applicant traversed the rejection of Claims 1-18 under 35 U.S.C. § 112, first paragraph, by arguing that the determination of the radius of curvature of each surface of the lens/mirror, the refractive index of each lens/mirror, etc., is routine and easily derived to one of ordinary skill in the art

with knowing the equation $\Delta L\cos\alpha > R/2$ is to be satisfied. In response to these arguments, the Examiner disagrees and states that without a boundary of numerical values of L or R disclosed in the specification, one skilled in the art does not have sufficient information to obtain the scanning focusing mechanism which satisfies the claimed equation without undue experimentation. The following is submitted in response to these comments.

The present inventor determined an optical system incorporating two lens systems that cover a wide scanning line, for example, needs to satisfy the claimed equation $\Delta L\cos\alpha < R/2$ to show the pixels are naturally consecutive at the connecting part of the two lens systems. The enclosed Figures 1-4 are enclosed to help explain the claimed invention.

In more detail, the enclosed Figures 1-4 illustrate a relationship between $\Delta L\cos\alpha$ and R at connecting parts of the two wide-angle lens systems in an optical system according to the present invention. That is, Figure 1 shows a proper condition of the connecting part as designed or after an appropriate adjustment. L1 and L2 are central light passage lengths, $\alpha 1$ and $\alpha 2$ are incident angles at the connecting part, and R is a beam pitch at the connecting part. At 400 dpi, for example, R is calculated as 25.4 mm/(400-1) = 63.7 μm.

Figure 2 shows another condition of the connecting part in which one of the central light passage lengths is shortened due to displacements of a mirror, a lens, and an LD or variations in the refractive index of these components caused by tolerances, variations in temperature, or distortions, for example. In the formulas shown in Figure 2, L1, L2, and L3 are central light passage lengths, $\alpha 1$ and $\alpha 2$ are incident angles at the connecting part, and R and R1 are beam pitches at the connecting part.

Figure 3 shows yet another condition of the connecting parting in which one of the central light passage lengths is extended due to displacements of a mirror, a lens, and an LD or variations in the refractive index of these components caused by tolerances, variations in temperature, or distortions, for example. In the formulas shown in Figure 3, L1, L2 and L4

are central light passage lengths, $\alpha 1$ and $\alpha 2$ are incident angles at the connecting part, and R and R2 are beam pitches at the connecting part.

Figure 4 shows still another condition of the connecting part in which the central light passage lengths are both extended due to displacements of a to-be-exposed area of the photoconductive drum caused by an eccentricity of the photoconductive drum, for example. In the formulas in Figure 4, L1, L2, L3, and L5 are central light passage lengths, $\alpha 1$ and $\alpha 2$ are incident angles at the connecting part, and R and R3 are beam pitches at the connecting part.

Further, there may be other variations in which the central light passage lengths are both extended and in which one of the central light passage lengths is extended and the other one of the central light passage length is shortened. However, these cases are omitted because the principles of their operation are similar to those discussed above.

In the conditions of the enclosed Figures 1-4, the above-mentioned changes ΔR, $\Delta R'$, and $(\Delta R+\Delta R')$ are important factors which show the connecting part to be disconnected or at least unnatural to human vision. That is, when these factors become greater than a predetermined value, the connecting part is at least seen as unnatural. Here, when the resolution is 400 dpi, for example, R in the proper condition is 63.7 μm. Experimentally, the present inventor determined that the connecting part is seen as separated or at least unnatural when the above-mentioned predetermined value is greater than half of R which is approximately 31.8 μm.

Based on the above, the present inventor determined that the optical system incorporating two lens systems that cover a wide range of scanning area needs to satisfy the claimed equation $\Delta L\cos\alpha < R/2$.

Independent Claims 1, 4 and 7 have been amended to more clearly recite these features. For example, independent Claim 1 is directed to an optical scanning apparatus

including two optical scanning systems, each having at least one light source configured to emit a light beam, at least one beam shaping mechanism configured to shape each light beam, and at least one scanning beam focusing mechanism configured to bring the scanning light beam to a focus on a photoconductive surface. Each scanning beam focusing mechanism satisfies the claimed equation $\Delta L\cos\alpha < R/2$ at a junction of the scanning light beams with each other on the photoconductive surface, where ΔL represents an inherent light pass length variation between central light passage lengths of the first and second optical scanning systems, α represents an incident angle, and R represents an inherent marginal distance. Independent Claims 4 and 7 have been similarly amended.

Accordingly, as shown in enclosed Figures 1-4, the values of the claimed equations may be determined without knowing the specific values for the optical components. Rather, the values L, R and α may be easily measured without undue experimentation to satisfy the claimed relationship so that the connecting part appears to be naturally consecutive.

Consequently, in light of the above discussion and in view of the present amendment, the present application is believed to be in condition for allowance and an early and favorable action to that effect is respectfully requested.

Respectfully submitted,

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IN THE SPECIFICATION

Please replace the paragraph beginning at page 3, line 13, with the following rewritten paragraph:

According to one aspect of the present invention, a novel optical scanning apparatus includes at least two light sources, at least two beam shaping mechanisms, a light deflector, and at least two scanning beam focusing mechanisms. Each of the two light sources is arranged and configured to emit a light beam. Each of the two beam shaping mechanisms is arranged and configured to shape the light beam. The light deflector is arranged and configured to deflect each light beam in a continuously changing direction thereby converting each light beam into a scanning light beam. Each of the two scanning beam focusing mechanisms is arranged and configured to bring the scanning light beam to a focus on a photoconductive surface. Each of the two scanning beam focusing mechanisms each of which produce a beam which satisfies an equation of [$\Delta L\cos\alpha > R/2$] $\underline{\Delta L\cos\alpha < R/2}$ at a junction of the first scanning light beam with the second scanning light beam on the photoconductive surface, wherein ΔL represents an inherent light pass length variation, α represents an incident angle, and R represents an inherent marginal distance.

Please replace the paragraph beginning at page 4, line 6, with the following rewritten paragraph:

According to another aspect of this invention, a method of optical scanning includes the steps of emitting at least two light beams, shaping the at least two light beams, deflecting each of the at least two light beams in a continuously changing direction thereby converting each of the at least two light beams into a scanning light beam, and bringing the scanning light beam to a focus on a photoconductive surface with at least two scanning beam focusing mechanisms each of which produce a beam. Each beam satisfies an equation of [$\Delta L\cos\alpha > R/2$] $\underline{\Delta L\cos\alpha < R/2}$ at a junction of the at least two scanning light beams with each other on the photoconductive surface, wherein ΔL represents an inherent light pass length variation, α represents an incident angle, and R represents an inherent marginal distance.

Please replace the paragraph beginning at page 4, line 20, with the following rewritten paragraph:

According to another aspect of the invention, an image forming apparatus includes a photoconductive member and an optical scanning apparatus. The optical scanning apparatus includes at least two light sources, at least two beam shaping mechanisms, a light deflector, and at least two scanning beam focusing mechanisms. Each of the two light sources is arranged and configured to emit a light beam. Each of the two beam shaping mechanisms is arranged and configured to shape the light beam. The light deflector is arranged and configured to deflect each light beam in a continuously changing direction thereby converting each light beam into a scanning light beam. Each of the two scanning beam focusing mechanisms is arranged and configured to bring the scanning light beam to a focus on a surface of the photoconductive member and satisfies an equation of [$\Delta L\cos\alpha > R/2$] $\underline{\Delta L\cos\alpha < R/2}$ at a junction of the at least two scanning light beams with each other on the surface of the photoconductive member, wherein ΔL represents an inherent light pass length variation, α represents an incident angle, and R represents an inherent marginal distance.

Please replace the paragraph beginning at page 5, line 14, with the following rewritten paragraph:

According to another aspect of the present invention, a method of image forming includes the steps of charging a surface of a photoconductive member, emitting at least two light beams, shaping the at least two light beams, deflecting each of the at least two light beams in a continuously changing direction so as to convert each of the at least two light beams into a scanning light beam, and bringing the at least two scanning light beams to a focus on the surface of he photoconductive member with at least two scanning beam focusing mechanisms. Each of the at least two scanning beam focusing mechanism which produce a beam which satisfies an equation of [$\Delta L\cos\alpha > R/2$] $\underline{\Delta L\cos\alpha < R/2}$ at a junction of the at least two scanning light beams with each other on the photoconductive surface, wherein ΔL represents an inherent light pass length variation, α represents an incident angle, and R represents an inherent marginal distance.

Please replace the paragraph beginning at page 13, line 18, with the following rewritten paragraph:

An optical scanning system includes the inherent marginal distance R and a light pass length variation ΔL which is also inherent to the optical scanning system. Accordingly, an optical scanning apparatus using the optical scanning system has an inherent marginal distance R and an inherent light pass length variation ΔL. To satisfy a required performance, an optical scanning apparatus [include] <u>includes</u> a mechanism for reducing the variations of the light pass length or correcting the displacement at the junction in accordance with the variations of the light pass length, or satisfying an equation [$\Delta L\cos\alpha > R/2$] $\underline{\Delta L\cos\alpha < R/2}$,